

*PERSISTENCE OF ACQUIRED BEHAVIORAL CONTROL
IN THE CONTEXT OF IMPRINTING¹*

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Newly hatched Khaki Campbell ducklings (*Anas platyrhynchos domesticus*) were exposed to a moving object that immediately suppressed distress vocalizations occurring in a novel environment. The static visual and auditory features of this object acquired the ability to suppress distress vocalizations after eight 20-min sessions of exposure to the object in motion. The acquired suppressive properties of these features were found to persist throughout thirty 20-min sessions given over 10 days. During these sessions, the ducklings were continually exposed to the static features in the absence of visual movement. In a second experiment, the ability of these features to serve as reinforcement for a pecking response was shown to persist for up to 56 hr. In one duckling, presentations of the static visual features did not maintain pecking behavior. However, it was shown that pecking responses could be re-instated in this duckling by introducing novel stimuli to the environment.

Key words: imprinting, novel stimuli, extinction, conditioned reinforcement, conditioned suppression, pecking, duckling

When a newly hatched duckling encounters an appropriate imprinting object for the first time, ongoing distress calls are rapidly suppressed (Hoffman, Stratton, and Newby, 1970). This suppression, which is generally considered a basic component of the filial response (Sluckin, 1965), is so immediate as to suggest that it represents an innate reaction to some aspect of the stimulation provided by the object. Several findings now point to the conclusion that with the kinds of stimuli used in most imprinting experiments the object's motion is the critical factor. Distress calling continues unabated if the duckling is first exposed to the sounds of the object without also seeing it move. Similarly, distress calling persists if the object is stationary and silent during its initial presentation (Hoffman *et al.*, 1970).

These findings imply that the static visual features of such objects (*e.g.*, their particular shapes, colors, and sizes), and the sounds produced during their movement are essentially neutral in their initial effects upon distress

vocalization. When, however, ducklings receive prolonged exposure to a given object in motion, both its static visual features and its auditory features gradually acquire strong suppressive properties (Hoffman, Eiserer, and Singer, 1972; Eiserer and Hoffman, 1974). Under the conditions of the experiments in which these effects were found, prolonged exposure to the object's static visual features and its auditory features by themselves was not sufficient to develop suppressive properties—that is, extended exposure to the object in motion was necessary.

In an effort to account for these effects, Hoffman and Ratner (1973) hypothesized that "imprinting is a process of primary reinforcement in which the distinctive (and initially neutral) features of a given stimulus gradually acquire the capacity to elicit filial behavior (p. 531)". According to this view, the acquisition of suppressive properties by these features is the essence of imprinting itself. It results from the association of these features with the innately reinforcing stimulation provided by visual motion.

In view of the importance of visual motion to the acquisition of suppressive properties by the initially neutral features of an imprinting object, the question arises as to the persistence of those properties once visual movement terminates. On an intuitive level, one might ex-

¹This research was supported by Grant MH 19715 from the National Institute of Mental Health, directed by Howard S. Hoffman. Reprints may be obtained from Howard S. Hoffman, Department of Psychology, Dalton Hall, Bryn Mawr College, Bryn Mawr, Pennsylvania 19010.

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pect that if the acquisition of this control depends upon motion, withholding visual motion should lead to an extinction process in which the suppressive properties become weaker and weaker. It seemed possible, however, that once acquisition occurs, its effects might be more or less permanent. Examples of relatively persistent acquisition effects have been reported in the literature of acquired food aversion (Garcia and Koelling, 1966), and it was conceivable that similar extinction-resistant effects might be obtained in the context of imprinting. This possibility was examined in Experiment I by first exposing ducklings to a visible moving object and then assessing the suppressive properties of the visual and auditory features of the object during a subsequent period, in which the ducklings received prolonged exposure to those features by themselves (*i.e.*, without visual movement).

GENERAL METHOD

Subjects

Each of the present experiments used a group of Khaki Campbell ducklings (*Anas platyrhynchos domesticus*) that were hatched in visual isolation from eggs obtained from George F. Shaw, Inc., West Chester, Pennsylvania. Except for periods spent in the experimental apparatus, each duckling was maintained in an individual housing unit consisting of a 15-gallon, white translucent container that was lined with a clear polyethylene bag and partially filled with bedding material. Under these circumstances, the ducklings could hear each other but their visual environment was restricted to that provided by the inside of their individual housing units. While in these

units, the ducklings had continuous access to food and water.

Apparatus

The experimental apparatus is illustrated in Figure 1. It consisted of a plywood box (122 by 76 by 76 cm) divided lengthwise by a fine-mesh stainless-steel screen into approximately equal compartments, one for the duckling and the other for the imprinting object. Lighting in the subject compartment was provided by two continuously illuminated 75-W incandescent lamps mounted above the screen. These lamps were positioned so that unless the stimulus compartment was also illuminated, the light that reflected from the stainless-steel screen prevented the subject from seeing into the stimulus compartment.

The imprinting object consisted of a white rectangular foam-rubber covering (22 by 10 by 10 cm) mounted over a model train engine that ran the length of the stimulus compartment on HO-gauge track. Presentations of the visible and audible moving object were produced by illuminating two overhead 75-W incandescent lamps in its compartment and moving the object back and forth along its track at approximately 30 cm per second. Presentations of only the static visual features of the imprinting object were produced by illuminating the two stimulus compartment lamps and withholding power from the engine that carried the imprinting object. Presentations of only the auditory features of the imprinting object were produced by moving the object back and forth along its track without illuminating the lamps in the stimulus compartment. The sound thus produced was a broad-band low-frequency noise that moved within the stimulus compartment; its average intensity was 67 dB *re*

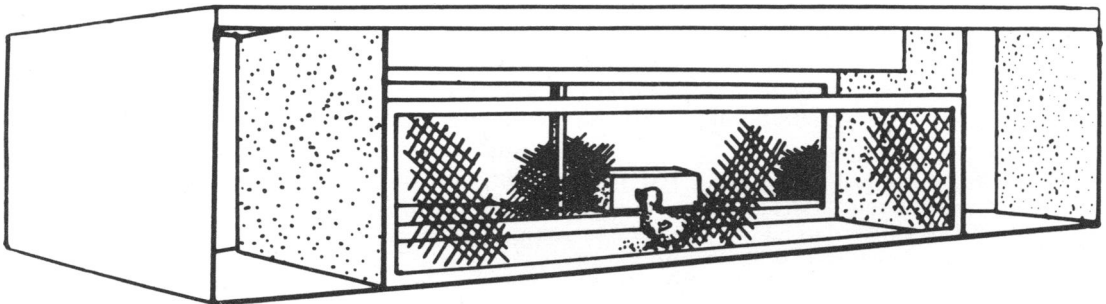


Fig. 1. Apparatus used for imprinting and subsequent test procedures.

0.0002 dyne/cm². Complete stimulus withdrawal was accomplished by extinguishing the lamps in the stimulus compartment and stopping the movement of the object.

Distress vocalization of the ducklings was monitored with a specially constructed voice key which, through selective filtering, was sensitive only to those sounds that fall in the frequency range characteristic of distress calls (approximately 3000 to 4000 Hz). In addition, subjects were periodically observed through a closed-circuit television system.

EXPERIMENT I

METHOD

Subjects

Five Khaki Campbell ducklings were used. Four (Birds 1 to 4) were employed in the main portion of the experiment; the fifth (Bird 5) was studied separately under a slightly different procedure.

Procedure

After hatching, each of the first four ducklings remained in the incubator for approximately 8 to 12 hr. Each subject was then transferred to the experimental apparatus and given a pre-imprinting distress vocalization test. This test consisted of three 20-sec presentations of the visible and audible moving object occurring in random sequence with three 20-sec presentations of the static visual features and with three 20-sec presentations of the auditory features; in other words, each of the three types of stimulus events occurred three times, comprising a randomly ordered sequence of nine stimulus presentations in total. Each stimulus presentation was preceded by a 20-sec period of complete stimulus withdrawal, during which baseline rate of distress vocalization could be assessed.

Following this test, and extending through the next three days, each duckling received eight imprinting sessions at the rate of two sessions per day. During these sessions, the visible and audible moving object was presented continuously for 20 min, after which the duckling was returned to its housing unit. After the last imprinting session on Day 4, each duckling was given a post-imprinting distress vocalization test that was identical in procedure to the pre-imprinting test.

Beginning on Day 5, each of the four ducklings was given three 20-min extinction sessions per day for the next 10 days. For Subjects B-1 and B-2, the visual features were used in the extinction sessions; for B-3 and B-4 the auditory features were used. Each extinction session consisted simply of placing the duckling in the apparatus and continuously exposing it to the appropriate test features in the absence of visual movement. At the end of each extinction period, the duckling was given a brief (three cycle) distress vocalization test where each cycle consisted of a 20-sec withdrawal of the test features, followed by a 20-sec presentation of those features. At no point in these sessions was the subject exposed to visual movement.

The procedure for the fifth duckling was identical to that for the other four subjects except that the 20-min extinction sessions were omitted. Thus, B-5 received eight imprinting sessions with the visible moving object, as well as the pre-imprinting and post-imprinting distress call tests; beginning on Day 5, however, B-5 merely received a daily three-cycle distress call test (with the visual features constituting the test features) without any intervening exposure to those features.

RESULTS

Figure 2 shows the results of the pre- and post-imprinting distress vocalization test for all five ducklings. During the pre-imprinting test, presentations of the moving object strongly suppressed baseline distress vocalization; presentations of either the visual features or the auditory features had little effect. However, during the post-imprinting test, presentations of the visual or auditory features, as well as presentations of the moving object itself, suppressed baseline distress vocalization almost completely.

These trends were verified by statistical analysis. An analysis of variance for repeated measures yielded a significant stimulus effect ($F = 21.67$, $df = 3,9$, $p < 0.05$), and a significant interaction between the effects of stimulus and imprinting ($F = 18.22$, $df = 3,9$, $p < 0.05$).

Suppression of distress calls by the test features during extinction was assessed by calculating the ratio $(B - TF)/(B + TF)$, where B represents seconds of distress vocalization that occurred during the several base-

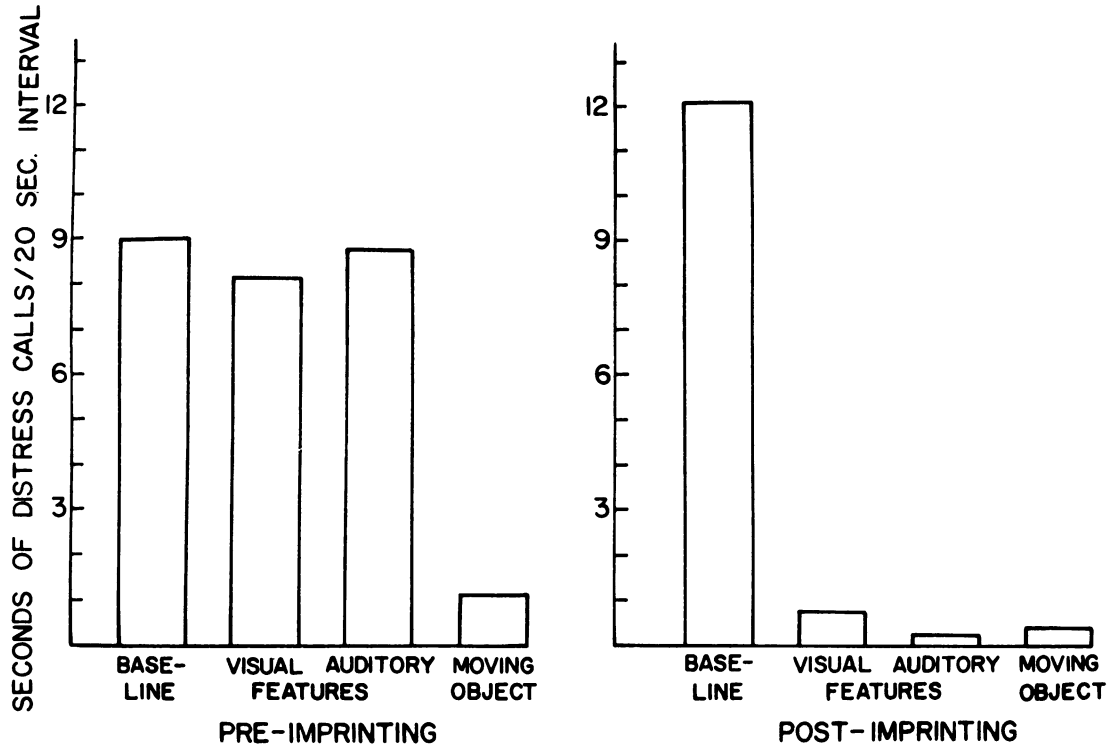


Fig. 2. Mean amount of distress vocalization for the five ducklings before (baseline) and during presentation of the moving imprinting object and its visual or auditory features. Amount of distress vocalization is shown before and after imprinting.

line intervals (*i.e.*, during the 20-sec intervals of complete stimulus withdrawal), and TF represents seconds of distress vocalization emitted during the 20-sec presentations of the test features. With this index, a ratio of +1.0 indicates perfect suppression by the features; ratios that approximate zero indicate that distress vocalization in the presence of the features was essentially the same as distress vocalization during stimulus withdrawal.

Although baseline rates of distress vocalization varied somewhat from bird to bird and from session to session, most birds vocalized for 10 to 13 sec per 20-sec of baseline (\bar{X} = 12.1 sec/20 sec for the five subjects). An analysis of variance for repeated measures failed to detect a reliable change in the rates of baseline distress vocalization across sessions.

Figure 3 shows the mean suppression ratios produced by presenting the test features to Birds 1 to 4 following each of the 30 extinction sessions. Across all these sessions, suppression by the visual features (for B-1 and B-2) and by the auditory features (for B-3 and B-4) remained very strong despite the continuing

absence of any accompanying visual movement. The range of suppression ratios over the 30 sessions for each bird were as follows: B-1 0.91 to 0.99, B-2 0.79 to 0.97, B-3 0.78 to 1.0 and B-4 0.63 to 1.0. An analysis of variance for repeated measures failed to detect either a reliable difference between the ratios afforded by the visual *versus* the auditory features, or a reliable change in the ratios generated by the two sets of features across sessions.

Observations of the behavior of B-1 and B-2, made periodically during the extinction sessions via the TV system, revealed that the ducklings spent most of each session sitting calmly and quietly in front of the stationary object. This behavior, which was occasionally interrupted by brief bouts of preening, was as characteristic of the thirtieth extinction session as of the first. In a similar fashion, B-3 and B-4 also spent a great proportion of their sessions sitting quietly in front of the stimulus compartment, although these ducklings also frequently paced back and forth along the fine-mesh screen as if follow-

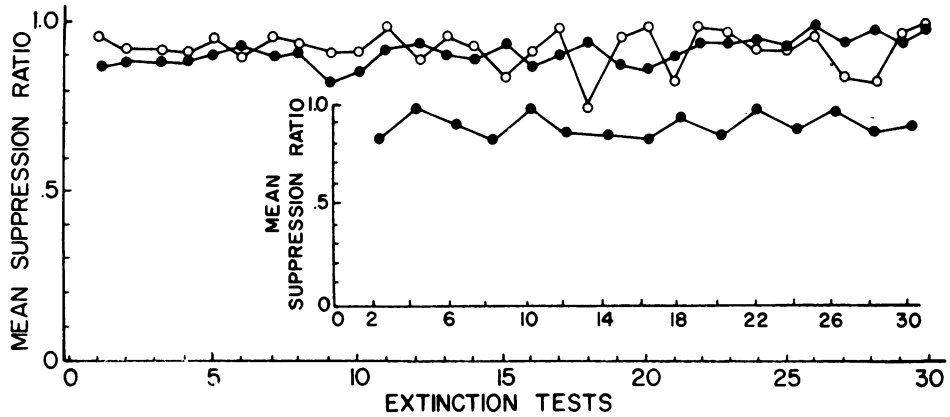


Fig. 3. Suppression of distress calls by the visual features (filled circles) and auditory features (unfilled circles) of the imprinting object during the tests that followed extinction sessions. During extinction sessions, subjects were exposed to the appropriate stimulus features in the absence of visual movement. The inset shows the suppression ratios for a subject (B-5) that was also repeatedly tested, but without intervening extinction sessions.

ing the moving auditory features. Again, the frequency of these behaviors did not change noticeably across the 30 sessions of extinction.

The suppression ratios produced by presenting the visual features to B-5 without any intervening exposure to those features are shown in the inset of Figure 3: suppression by the visual features remained strong across the 30 distress-call tests. These data, in combination with those from Birds 1 to 4, make it apparent that after acquiring suppressive properties through association with visual movement, the initially neutral features of an imprinting object can maintain those properties, even though visual movement is subsequently withheld. While present results do not permit the conclusion that the acquired suppressive properties will persist indefinitely in the absence of visual movement, they do suggest that such properties persist for a relatively long time.

EXPERIMENT II

After acquiring suppressive properties, the static visual features of an imprinting object can be used to strengthen or reinforce an operant response. Eiserer and Hoffman (1973) trained ducklings to peck a pole with brief presentations of the visual features as the sole reinforcing event. Experiment II investigated the persistence of reinforcement properties of visual and auditory features in the absence of any further association with visual movement.

METHOD

Subjects

Three newly hatched Khaki Campbell ducklings (Birds 6 to 8) were used.

Apparatus

A balsa-wood pole (1 by 1 by 30 cm) was mounted on the wall above the center of the screen so that it hung down vertically to the floor of the subject compartment. Pecks on this pole initiated presentation of a given stimulus condition for a specified duration. The peck force required was approximately 2 g (0.2 N).

A further stimulus condition was added to those of Experiment I, consisting of illuminating the empty stimulus compartment, the imprinting object having been previously removed.

Procedure

Each duckling was exposed to the visible moving object in two 20-min imprinting sessions per day for the first four days posthatch. After the eighth imprinting session, an informal distress vocalization test verified that both the visual and the auditory features almost completely suppressed ongoing distress vocalization when presented without any accompanying visual motion.

Beginning on Day 5 posthatch, each subject was trained to peck the pole, with presentation of the visible moving object as reinforcement. During these procedures, the

experimenter observed the duckling via closed-circuit television and presented the visible moving object very briefly (approximately 0.5 sec) when the bird approached the pole. Once the duckling was in the vicinity of the pole, only those motions that more and more closely resembled a pole peck were reinforced until such time as the duckling actually pecked the pole.

The first peck produced the visible moving object for 5 sec, but as the response became more frequent, duration was increased to 15 sec. Since the timer controlling presentation of the object did not reset with additional responses after the one that initiated the 15-sec presentation, time for object presence did not accumulate. As a result, presentation of the imprinting object did not continue uninterrupted.

After the pecking response was firmly established (after approximately 2 hr of reinforcing each peck) each duckling was exposed to a variety of response contingencies. The specific sequence and duration of exposure to each contingency differed among the three birds and is detailed during the discussion of their effects. Throughout all experimental sessions, food and water were continuously available to each duckling.

RESULTS

Figure 4 shows the average response rates of Bird 6 during its final exposure to reinforcement by the visible moving stimulus and during subsequent sessions where pecks either produced the sound (but not sight) of the imprinting stimulus or were without effect (a condition herein described as pole-peck extinction). Over Days 5 to 8, Bird 6 was given four experimental sessions that averaged 4.5 hr in length (range = 4 to 5 hr). On Day 9, B-6 inexplicably died in its housing unit.

As can be seen in the figure, B-6 responded at a high rate during hours 1 to 2 when each peck was reinforced by a 15-sec presentation of the visible moving object ($\bar{X} = 3.36$ pecks per minute, with maximum possible of four per minute). Responding remained at a high level during hours 3 to 10 when each peck was reinforced by a 15-sec presentation of the auditory features alone ($\bar{X} = 2.99$ pecks per minute). When pole-peck extinction procedures were instituted during hours 11 to 13, responding quickly declined. High response rates resumed during hours 14 to 18 when pecks were again reinforced with presentations of the auditory features ($\bar{X} = 2.72$ pecks per minute).

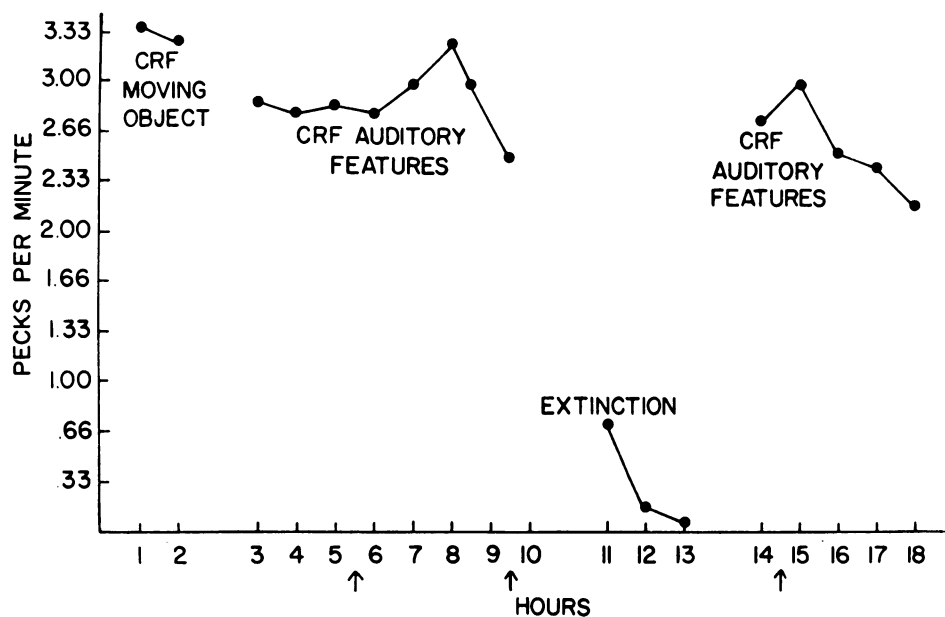


Fig. 4. Key-peck rates for Subject B-6 during continuous reinforcement (CRF) schedules, in which each peck produced the moving imprinting object or its auditory features, and during extinction. Arrows indicate breaks between sessions.

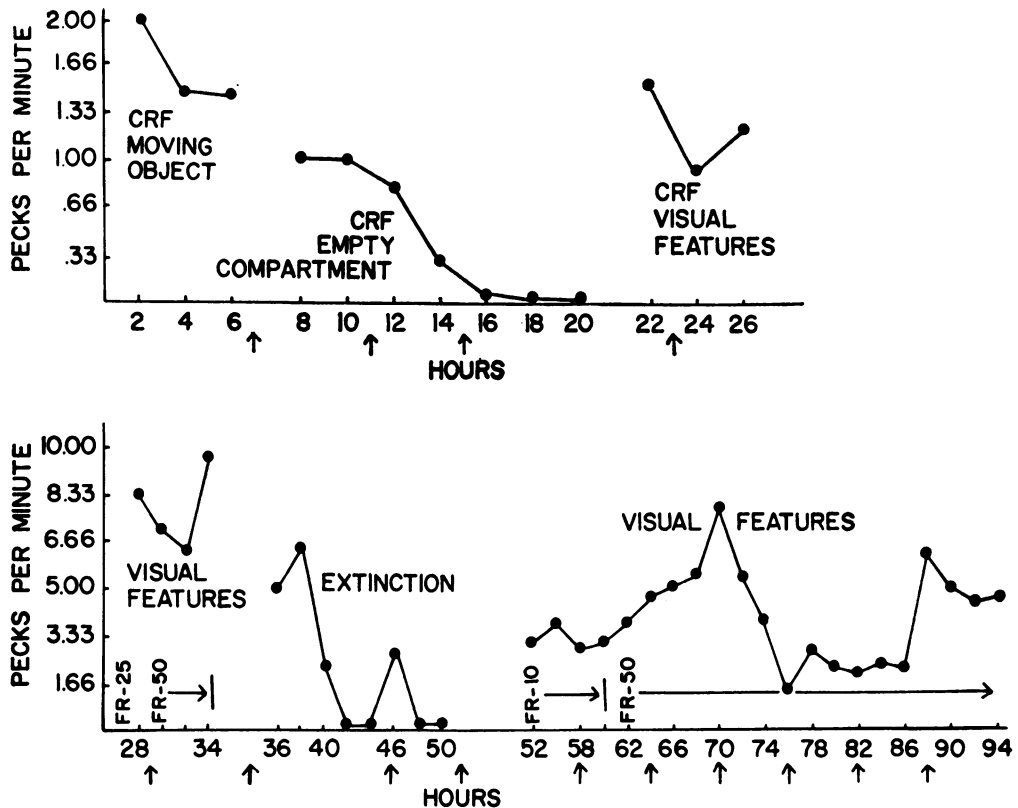


Fig. 5. Key-peck rates for Subject B-7 during continuous reinforcement (CRF), fixed-ratio, and extinction sessions. The moving imprinting object, its visual features, or an empty stimulus compartment were reinforcements. Arrows indicate breaks between sessions. Note the difference in ordinate unit size in the two graphs.

Bird 7 received 15 sessions at the rate of one session per day; these sessions averaged 6.1 hr in length (range = 4 to 10 hr). As can be seen in Figure 5, B-7 responded at a relatively high rate during hours 1 to 6 when each peck was reinforced by a 15-sec presentation of the visible moving object ($\bar{X} = 1.64$ pecks per minute). When each peck produced a 15-sec presentation of the illuminated but empty stimulus compartment (hours 7 to 20), response rates gradually declined until B-7 ceased pecking altogether. When each peck produced 15-sec presentations of the visual features (hours 21 to 26), B-7 resumed responding at a substantial rate ($\bar{X} = 1.21$ pecks per minute).

At the beginning of hour 27, reinforcement with the visual features occurred on a fixed-ratio schedule that gradually increased up to FR 25 within the first 20 min and then stayed at that ratio for the next 90 min. The ratio requirement was then increased to FR 50 for the next 6 hr (hours 28 to 34). A high response

rate was maintained throughout this period ($\bar{X} = 8.76$ pecks per minute; these rates are much higher than during periods of continuous reinforcement (FR 1) since the latter condition dictated a minimum interval of 15 sec between reinforced responses). When pole-peck extinction was then instituted during hours 35 to 50, response rates declined to zero. Finally, when the visual features were again presented on a schedule of FR 10 (hours 51 to 58), responding resumed and was maintained on an FR 50 for the next 36 hr (hours 59 to 94). Average rate of responding throughout this latter period was 4.87 pecks per minute.

Figure 6 contains the response rates of Bird 8. B-8 received 10 sessions that averaged 5.1 hr in length (range = 4 to 8 hr) between Days 5 to 14 posthatch. From hours 1 to 26, when each peck was reinforced with a presentation of the moving object, B-8 emitted high and stable response rates ($\bar{X} = 2.35$ pecks per minute). A high response rate also occurred during hours 27 to 30 when pecks were reinforced

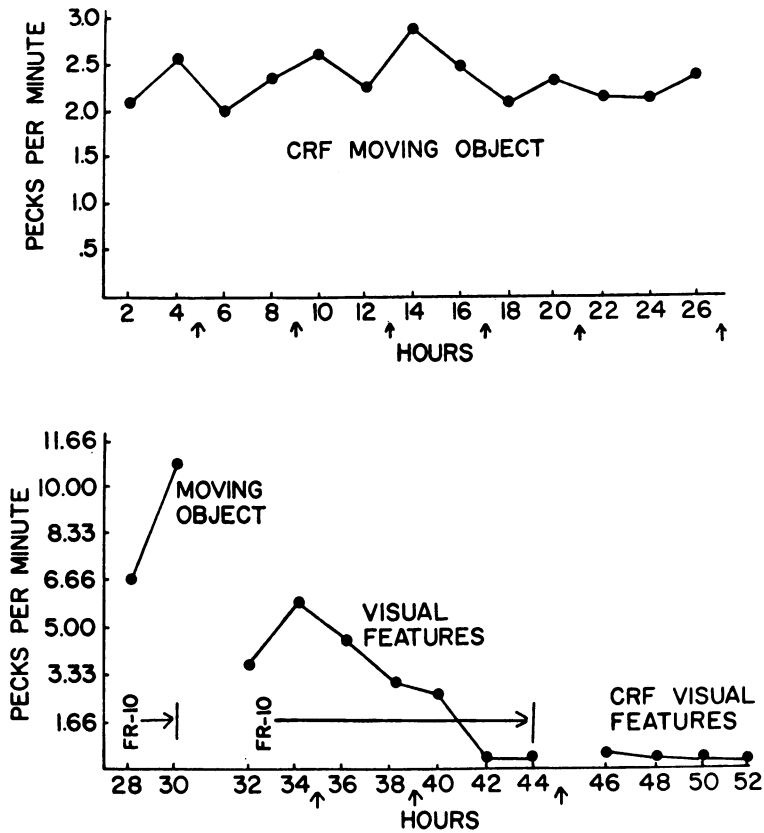


Fig. 6. Response rates for Subject B-8 during continuous reinforcement with the moving imprinting object (CRF) and during various fixed-ratio schedules using presentation of the visual features of the stationary imprinting object as reinforcement. Arrows indicate breaks between sessions. Note the difference in ordinate unit size in the two graphs.

with the moving object on FR 10 (\bar{X} = 8.6 pecks per minute). However, when responses were reinforced by presentations of the visual features on FR 10 during hours 31 to 44, responding gradually declined to zero. B-8 did not resume responding even when the ratio was changed back to FR 1 (during hours 45 to 52).

DISCUSSION

The results generated by B-6 indicate that the reinforcing properties of the auditory features persisted for a total of 13 hr in the absence of any accompanying visual movement. Moreover, the marked decline in responding that occurred when the auditory features were not presented (*i.e.*, during extinction) confirms that the auditory features themselves maintained responding during the periods in which they served as reinforcement.

The results obtained with B-7 suggest a

comparable conclusion with regard to the visual features. Although B-7 stopped responding during extinction, as well as when pecks produced the empty stimulus compartment, the duckling emitted high rates of responding when each peck produced a presentation of the visual features. Moreover, relatively high response rates persisted during the 36-hr period in which pecks were reinforced with the visual features on an FR 50 schedule

Although the findings for B-6 and B-7 indicate that the visual and auditory features of the imprinting object can maintain their reinforcing properties for a long time in the absence of visual movement, the data generated by B-8 draw a somewhat different picture. With this duckling, the visual features failed to maintain responding whether those features followed every tenth response or whether they followed each response. These results might

be taken to indicate that the visual features had lost the properties that they had previously acquired through association with visual movement. To test this possibility, a supplementary experiment was conducted using B-8 as the sole subject. During the first part of this experiment, the ability of the visual features to suppress ongoing distress calls was retested.

EXPERIMENT III

To assess the suppressive properties of a stimulus, it is first necessary to induce a measurable rate of distress calling against which suppression can be detected. By the end of Experiment II, however, B-8 had received such lengthy exposure to the experimental apparatus (and had presumably habituated thoroughly to all of its stimulus features) that we anticipated difficulty in obtaining sufficient rates of baseline distress vocalization against which suppression by the visual features of the imprinting object could be assessed. Consequently, for the purposes of Experiment III, a novel stimulus, known to elicit substantial rates of distress vocalization in older ducklings (see Eiserer and Hoffman, 1973), was introduced.

METHOD

Apparatus

The balsa-wood pole was removed from the subject compartment and an amber-colored rotating lamp (of the sort used on the top of many emergency vehicles) was placed outside of the apparatus opposite to the position formerly occupied by the pole. Since the screen between the lamp and the subject compartment provided a one-way vision effect, presentation and withdrawal of the lamp could be controlled by the experimenter. The lamp was presented by illuminating its bulb and rotating its lens system. Withdrawal of the lamp involved extinguishing the bulb and terminating rotation.

Procedure

The reassessment of the visual features' suppressive properties took place on Day 15 posthatch. B-8 was placed in the apparatus while the imprinting object was absent. Then, two different types of stimulus presentations occurred in random order: either (1) the rotating lamp and the visual features were

presented simultaneously for 2 min, or (2) the rotating lamp and the illuminated but empty stimulus compartment were presented simultaneously for 2 min. Four presentations of each type were given, with a 2-min baseline period of stimulus withdrawal preceding each of the presentations.

Shortly after the above procedures were completed, the reinforcing properties of the visual features (*i.e.*, in maintaining pecking) were reassessed in the context of the novel stimulus. This part of the experiment, for which the balsa-wood pole was re-instated into the apparatus, consisted of two phases. During the first phase, each pole-peck was followed by a 15-sec presentation of the static visual features of the imprinting object. For 1 hr after B-8 was placed in the apparatus, the rotating lamp was not presented. Then, four 2-min presentations of the lamp were given, with each presentation being followed by a 20-min period of lamp withdrawal. After the fourth lamp presentation, B-8 was returned to its housing unit for 1 hr. Then began the second phase of the experiment, which was identical in procedure to the first phase except that the imprinting object was removed from the apparatus, so that each peck by B-8 was followed by a 15-sec presentation of the illuminated but empty stimulus compartment.

After the second phase was completed, B-8 remained in the apparatus for an additional hour. Throughout this period, during which the rotating lamp remained withdrawn, each peck by B-8 produced a 15-sec presentation of the visible moving object.

RESULTS

Television observations during the test of the visual features' suppressive properties revealed that B-8 usually ran about the subject compartment and emitted high rates of distress calling during the joint presentations of the empty stimulus compartment and the rotating lamp. However, when the stationary object could be seen during presentation of the rotating lamp, B-8 stopped emitting distress calls and vigorously brushed against the fine-mesh screen in apparent efforts to get closer to it. During the intervening baseline periods, when neither the rotating lamp nor the stationary imprinting object were visible, B-8 usually sat quietly near the screen that bordered the stimulus compartment.

Figure 7a shows the average amounts of distress vocalization emitted by B-8 during the several test conditions. A high rate of distress vocalization occurred when the empty stimulus compartment was presented with the rotating lamp, but almost no distress vocalization occurred when the visual features were visible during lamp presentation. During the periods when neither the rotating lamp nor the stationary object were visible, little distress vocalization occurred. The reliability of these effects was substantiated by an analysis of variance ($F = 43.0$, $df = 3,12$, $p < 0.05$).

Figure 7b shows the average number of pole pecks occurring during the two sets of presentations of the rotating lamp (Lamp + Visual Features Available, and Lamp + Empty Compartment Available) in the reassessment of the reinforcing properties of the visual features. Also shown are the average number of responses given during the 2-min periods that immediately preceded each of the lamp presentations (Visual Features Available, and Empty Compartment Available). Few pecks occurred during the absence of the rotating lamp, whether pecks produced the visual features or the empty stimulus compartment. When the rotating lamp was presented, however, B-8 emitted a substantial number of pecks when reinforcement consisted of presentation of the visual features, although virtually no pecks occurred when reinforcement consisted of the illuminated but empty compartment. The reliability of these trends was confirmed by an analysis of variance ($F = 14.9$, $df = 3,12$, $p < 0.05$).

During the final hour of the experiment, when the rotating lamp remained withdrawn and each peck produced the visible moving object, B-8 gave a total of 83 responses.

GENERAL DISCUSSION

When presented against the background of a novel stimulus, the static visual features of the imprinting object displayed strong suppressive properties as well as reliable reinforcing properties, even though these features had not been reassociated with visual movement since Experiment II. The fact that under identical conditions, the empty but illuminated stimulus compartment neither suppressed distress calls nor maintained pecking clearly indicates that the rotating lamp

did not simply induce a general reappearance of those behaviors in response to stimulus change *per se*. Rather, the responses of B-8 were specifically directed towards the visual features themselves.

These results contrast sharply with those of Experiment II, in which presentations of the static visual features were insufficient to maintain the responses of B-8. Apparently, the suppressive and reinforcing properties of the visual features of an imprinting object can remain latent in an environment to which the duckling is well habituated (*i.e.*, one that no longer elicits distress calling), but may subsequently become detectable when novelty is introduced into that environment. Given the behavior of B-8 during presentation of the rotating lamp (*i.e.*, distress calling and frantic running), it seems reasonable to suggest that presentation of the lamp elicited an aversive reaction, and that this reaction was reduced by stimulation from the imprinting object. The finding of Experiment III, that presentation of the visual features elicited both approach responses and suppression of distress calls, is consistent with this view, in that the stationary imprinting object reduced the running and distress calling of the duckling.

In Experiment II, B-7 continued to peck when the visual features were response produced, even after receiving as much exposure to the experimental chamber as B-8. Ducklings, however, typically exhibit wide individual variation in the rate at which they habituate to (*i.e.*, cease giving distress calls in response to) novel stimuli. Thus, it is possible that throughout Experiment II, B-7 habituated to the stimulus features of the chamber to a lesser extent than B-8 did. This might explain why B-7 continued to peck for the visual features while B-8 stopped.

A final question raised by the present results is why, at the end of Experiment III, the visible moving object maintained pecking by B-8 (83 responses in 1 hr) under conditions in which the object's static visual features had failed to induce responding (*i.e.*, when the rotating lamp remained withdrawn). This difference may perhaps be understood in terms of the behavioral aftereffects that follow presentations of the moving object and its visual features. Previous work in our laboratory has found that a brief presentation of the moving object increases the subsequent tendency of a

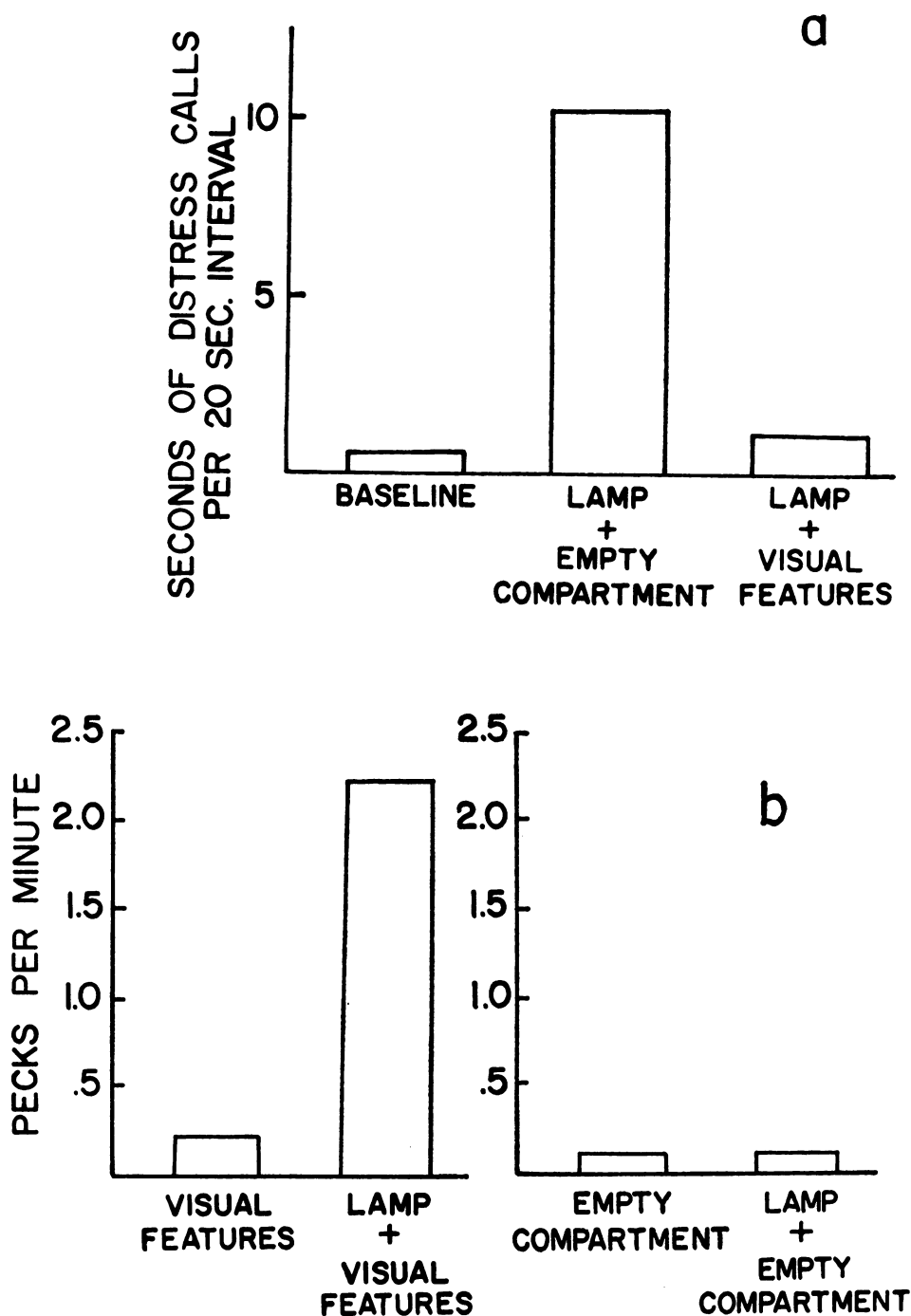


Fig. 7. (a) Amount of distress vocalization emitted by Subject B-8 during either complete stimulus withdrawal (baseline) or presentation of the rotating lamp and with or without the simultaneous presentation of the visual features of the imprinting object. (b) Key-peck rates for Subject B-8 with and without the presence of the rotating lamp. Each peck produced either the visual features of the imprinting object or an empty stimulus compartment.

duckling to seek further stimulation of the same sort—for example, to perform an operant that has previously been reinforced with the moving object (Eiserer and Hoffman, 1973). Brief presentations of the static visual features, however, failed to have any detectable effect upon ducklings' subsequent response tendency. Presumably in the present experiment, each time B-8 pecked, the resulting stimulus presentation of the visible moving object itself induced an increase in the duckling's tendency to peck again, and a sort of self-perpetuating process was initiated. When, however, B-8 pecked and the static visual features were presented, the resulting increase in response tendency was presumably minimal, and responding was not maintained (*i.e.*, unless the novel stimulus was presented).

Earlier research (Hoffman, Eiserer, and Singer, 1972; Eiserer and Hoffman, 1974) has revealed that acquisition of suppressive and reinforcing properties by the visual and auditory features of an imprinting object depends upon the prior association of these features with the innately reinforcing stimulation provided by visual movement. Once a duckling has received sufficient exposure to an appropriate moving object, the static features of that object acquire the capacity themselves to control the positive affective reactions that initially were elicited only by visual motion. The present results indicated that once the visual and auditory features gain these suppressive and reinforcing properties, they maintain them for prolonged periods in the subsequent absence of any further association with visual movement.

It should be noted that these results seemingly contradict findings reported by Peterson (1960). In Peterson's study, ducklings that had been trained to peck a key for presentations of the moving imprinting object stopped responding within a short period when the re-

inforcement contingencies were changed so that presentations of the stationary imprinting object followed responses. In our Experiment II, two of three ducklings persistently responded (for 13 and 56 hr, respectively) for presentations of the auditory and visual features of the imprinting object in the continued absence of accompanying visual movement. There were, however, several differences between Peterson's study and the present work, including the amount of exposure to the moving object, the conspicuousness of that object, the location of the manipulandum, and the sequence of reinforcement contingencies. Consequently, the exact cause of the discrepant findings cannot be evaluated without further research.

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Received 2 January 1975.

(Final Acceptance 23 July 1975.)